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COMMON CONTROL BY COMPOUND SAMPLES IN CONDITIONAL DISCRIMINATIONS

LUIS ANTONIO PÉREZ-GONZÁLEZ AND BENIGNO ALONSO-ÁLVAREZ

UNIVERSITY OF OVIEDO, SPAIN

We tested whether teaching control by single stimulus samples in conditional discriminations would result in common control of two-stimuli compound samples, and vice versa. In Experiment 1, 5 participants were first taught four single-sample conditional discriminations. The first conditional discrimination was as follows: given sample stimulus P1, select comparison stimulus A1 and not A2; given sample P2 select comparison A2 and not A1. The second conditional discrimination was as follows: given sample P1 select comparison B1 and not B2; given sample P2 select B2 and not B1. Different sample stimuli (Q1 and Q2) were used in the third and fourth conditional discriminations. Moreover, A1 and B1 were presented together as comparisons, such that, if Q1 was presented as the sample, A1 was correct and B1 was incorrect; and if Q2 was presented as the sample, B1 was correct and A1 was incorrect. A2 and B2 were also presented as comparisons. When Q1 was presented, A2 was correct and when Q2 was presented B2 was correct. After training with these four single stimulus sample discriminations, participants were tested with compound PQ samples presented with A1, A2, B1, and B2 as comparisons. If common control were established by the PQ stimuli, a participant would select A1 when P1Q1 was presented, A2 when P2Q1 was presented, B1 when P1Q2 was presented, and B2 when P2Q2 was presented. Such common control by PQ samples occurred in 4 of 5 participants. In Experiment 2, 4 participants were given reverse training. They were first taught to select the A1, A2, B1, and B2 stimuli in response to the appropriate PQ combinations and then probed on the single stimulus sample discriminations. All 4 participants were successful on this probe. Experiments 3 and 4 investigated the effects of teaching additional conditional discriminations with novel stimuli on subsequent transfer from the single-sample discriminations to performance on the compound-sample conditional discrimination.

Key words: restricted control, conditional discriminations, compound-samples, emergent relations, stimulus equivalence, adults

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Studies on stimulus equivalence and stimulus relations have explored many basic processes analogous to those involved in verbal behavior (e.g., Hayes, Barnes-Holmes, & Roche, 2001; Sidman, 1971, 1994; Sidman & Cresson, 1973, Sidman, Cresson & Willson-Morris, 1974). Examples of research conducted on topics that model some of the complexities of verbal behavior are studies of contextual control (e.g., Bush, Sidman & de Rose, 1989; Lynch & Green, 1991; Markham & Dougher, 1993; Meehan & Fields, 1995; Pérez-González, 1991; Pérez-González & Martínez-Sánchez, 2007; Pérez-González & Serna, 1993a, 1993b, 2003; Pérez-González, Spradlin, & Saunders, 2000; Roche & Barnes, 1996, 1997; Serna, 1991; Serna & Pérez-González, 1994, 1997, 2003; Wulfert & Hayes, 1988; see theoretical analyses in Sidman, 1986, 1994), relations among relations and stimuli (e.g. Carpentier, Smeets, & Barnes-Holmes, 2000, 2002a, 2002b; Junior & Costa, 2003; Junior, Costa, Gonsales, & Golfeto, 2001; Pérez-González, 1994), studies on relations between relations, or analogical reasoning (Pérez-González, Herszlikowicz, & Williams, 2008; Stewart, Barnes-Holmes, Roche, & Smeets, 2001, 2002), and comparative relations ''more'' and ''less'' (Dymond & Barnes, 1995, 1996). Hayes, Barnes-Holmes, and Roche summarized these studies, and interpreted them in terms of Relational Frame Theory. In spite of many studies being conducted, many basic processes analogous to those involved in verbal behavior have not yet been studied in detail. For example, suppose a child is taught to select ''Cervantes'' (instead of ''Goya'') or ''Balzac'' (instead of ''Gauguin'') when asked to select a writer and to select ''Goya'' (instead of ''Cervantes'') or ''Gauguin'' (instead of ''Balzac'') when asked to select a painter. The child might then be taught to select ''Cervantes'' (instead of ''Balzac'') or ''Goya'' (instead of ''Gauguin'') when asked to select the Spanish person and to

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Address correspondence to Luis A. Pérez-González, Departamento de Psicología, University of Oviedo, Plaza Feijoo s/n, Oviedo 33003, Asturias, Spain (e-mail: laperez@uniovi.es).

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select ''Balzac'' (instead of ''Cervantes'') or ''Gauguin'' (instead of ''Goya'') when asked to select the French person. A question that arises at this point is whether the child would then be able to correctly select ''Cervantes'' in response to the direction, ''Select a Spanish writer'', when the comparison words were ''Cervantes,'' ''Goya,'' ''Balzac,'' and ''Gauguin.'' If the child does so, it could be said that the compound stimulus, Spanish writer, had acquired common control over the child's response.

Several researchers have studied the relations that emerge when compound stimuli are used as samples in interrelated conditional discriminations (e.g., Augustson, Dougher, & Markham, 2000; Markham & Dougher, 1993; Smeets, Schenk, & Barnes, 1994; Stromer & Mackay, 1990; Stromer & Stromer, 1990a, 1990b; also, the studies on contextual control cited above). None of these studies, however, addressed the issues involved in the above example. In previous research Alonso-Álvarez & Pérez-González (2006) conducted two studies that were more closely analogous to the example presented above. In Study 1, we taught two conditional discriminations, labeled P–A and P–B, which were intended to be analogous to teaching that ''Cervantes'' and ''Balzac'' were writers and that ''Goya'' and ''Gauguin'' were painters. On these trials either P1 (writer) or P2 (painter) were presented as samples, and the comparison arrays were either A1 (Cervantes) and A2 (Goya) or B1 (Balzac) and B2 (Gauguin). Then, we taught two more conditional discriminations, labeled Q–1 and Q–2, intended to be analogous to teaching that ''Cervantes'' and ''Goya'' were Spanish and that ''Balzac'' and ''Gauguin'' were French. In this conditional discrimination, Q1 (Spanish) or Q2 (French) served as samples, and the comparisons remained the same. However, the comparison arrays were different. Sample Q1 (Spanish) was presented with comparisons A1 and *B1* (Cervantes and Balzac), and sample Q2 (French) was presented with comparisons A2 and *B2* (Goya and Gauguin). This teaching was intended to establish the following relations: P1–A1, P1–B1, P2–A2, P2–B2, Q1–A1, Q1–A2, Q2–B1, and Q2–B2. Trials from the four conditional discriminations were not intermixed for additional teaching. Following this teaching, PQ probe trials were introduced that were intended to be analogous to requests to ''Name a Spanish writer,'' ''Name a Spanish painter,'' ''Name a French painter,'' and, ''Name a French writer.'' In these test trials, compound samples were formed with combinations of P and Q stimuli. Stimuli A1, A2, B1, and B2 were the comparisons on all trials. The comparison defined as correct was the one that had been previously related to both elements of the compound sample. Thus, in the presence of compound P1 and Q1 (writer and Spanish), the correct comparison was A1 (Cervantes). Neither of the 2 participants given this teaching succeeded on the probe using compound samples. In Study 2 trials from the four single-sample conditional discriminations were intermixed and taught to a criterion of 16 consecutive correct responses with feedback followed by a session with no feedback and the same criterion. After this teaching, both of the adult participants in Study 2 responded correctly on the probe trials involving compound PQ samples.

Experiment 1 of the current research was designed to replicate Study 2 of the previous research with more participants. Experiment 2 of the current research was designed to determine if single-sample control would emerge after compound-sample stimulus training. It is important to note that the processes involved in the emergence of the compound-sample conditional discrimination of Experiment 1 and the processes involved in the emergence of the four single-sample conditional discriminations of Experiment 2 are different. Experiment 1 involves combining the control of stimuli whose control has been established in isolation. Whereas Experiment 2 involves separating the control of stimuli whose control has been established in compound samples.

The third goal of the present research was to analyze conditions under which control by compound stimuli after single-sample conditional discrimination teaching occurs. Previous studies on compound-sample conditional discriminations have resulted in several theoretical interpretations. For example, Sidman (1994) suggested that individual stimuli could belong simultaneously to two intersecting classes. Stromer, McIlvane, and Serna (1993) proposed that sample stimuli and correct comparisons form a compound. Yet, advocates of Relational Frame Theory proposed that stimulus relations are sometimes too complex

and, hence, they can be hierarchical (e.g., Hayes, Fox, Gifford, Willson, & Healy, 2001). The procedures used in the present studies and the analysis of the factors involved in this type of emergence may address the question of what processes proposed by these theories result in compound control. Finally, because the long-term goal of this series of studies is to analyze the complex discriminative processes involved in early development, it is important to determine whether the task requirements are beyond the skills of normal young adults and adolescents. Moreover if some of these normal young adults fail, the failures may cast light on the determinants of successful performance.

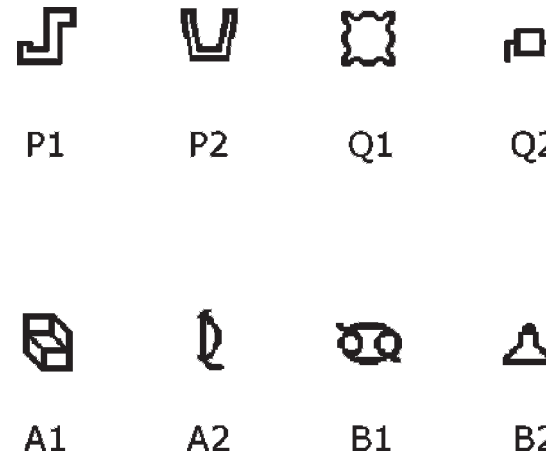

Fig. 1. Shapes used as stimuli in Experiments 1 to 4.

EXPERIMENT 1

Method

Participants

Participants were 4 female (SOLA, EVIA, TESA, DESA) and 1 male (DIEIO) Spanish-speaking undergraduate students from the School of Psychology at the University of Oviedo. All of the participants were acquaintances of the second author and were between 18 and 21 years of age, unfamiliar with stimulus equivalence research. They received no compensation for participating in the study and were not given information regarding the aims of the study until after its completion.

Setting, Materials, and Stimuli

Experimental sessions were conducted in a quiet room, with a table, a chair, and a computer, in a laboratory in the psychology department. During each session, presentation of stimuli and consequences and recording of the participants' responses were controlled by a Macintosh computer equipped with software developed by Dube (1991) and modified by the present experimenters. The computer screen was divided so that there were four squares at the corners of the screen and one square at the center of the screen. Sample stimuli were presented in the center block, and comparison stimuli were presented at the corners. The stimuli were black visual forms (see Figure 1) about 2 cm wide × 3 cm high presented on a white background. The trained and tested conditional discriminations appear in Figure 2. A depiction of the trained relations appears in Figure 3. The stimuli designated as P1, P2, Q1, and Q2 served as samples. The stimuli designated as A1, A2, B1, and B2 served as comparisons.

During training trials, selections of the correct comparisons were followed by the presentation of a visual display and a brief period of music. When participants selected an incorrect comparison, the screen turned blank for 3 s. On probe trials, no differential consequences were provided. All responses (either correct or incorrect) were followed by an intertrial interval of 1.5 s and the presentation of the next trial.

Procedure

Training consisted of teaching four single-sample conditional discriminations (P–A, P–B, Q–1, and Q–2). In conditional discrimination P–A, selections of comparison A1 in the presence of sample P1 and selections of comparison A2 in the presence of sample P2 were reinforced. In conditional discrimination P–B, selections of comparison B1 in the presence of sample P1 and selections of comparison B2 in the presence of sample P2 were reinforced. In summary, in the P–A and the P–B conditional discriminations, selections of comparisons A1 and B1 in the presence of sample P1 and selections of comparisons A2 and B2 in the presence of sample P2 were reinforced.

On all trials of conditional discriminations Q–1 and Q–2, either A1 and B1 or A2 and B2 were presented together as comparisons, and either Q1 or Q2 were presented as the

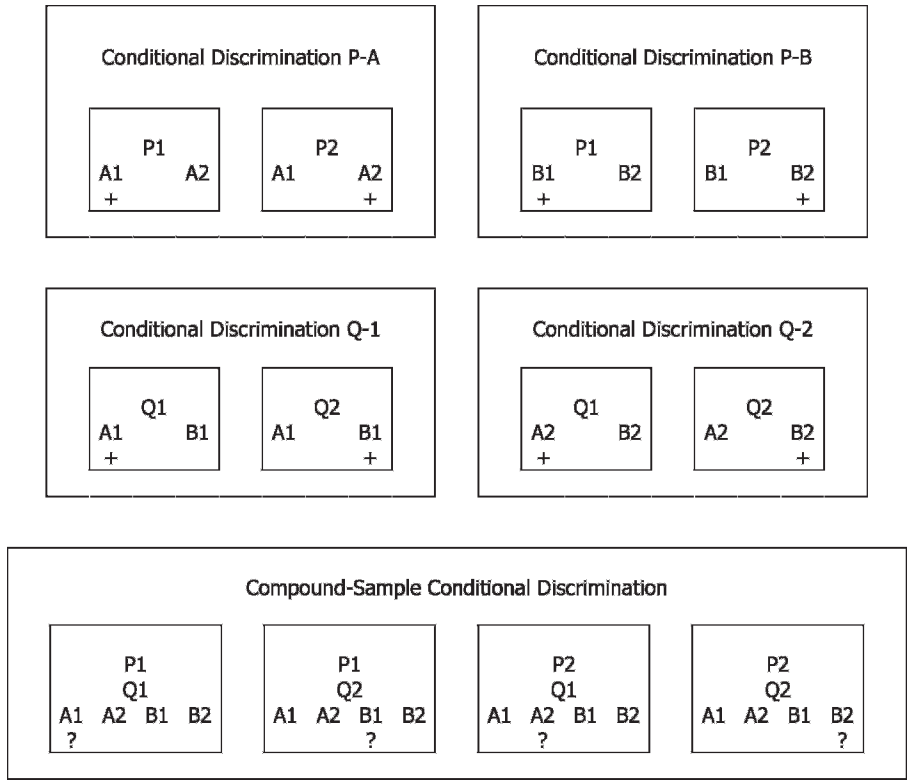

Fig. 2. Conditional discriminations. Participants in Experiments 1, 3, and 4 learned single-sample conditional discriminations P–A, P–B, Q–1, and Q–2 and received probes of the compound-sample conditional discrimination. Each box shows a trial type. The stimulus or stimuli that appear in the upper part of each box were the samples; the stimuli that appear at the bottom of each box were the comparisons (the actual locations varied randomly; see text). The plus sign indicates the comparisons for which selection was reinforced in learning phases. The question mark indicates the comparison for which selection was considered correct in the probes. In Experiment 2, and portions of Experiments 3 and 4, participants learned the compound-sample conditional discrimination and received probes of single-sample conditional discriminations (see text for details).

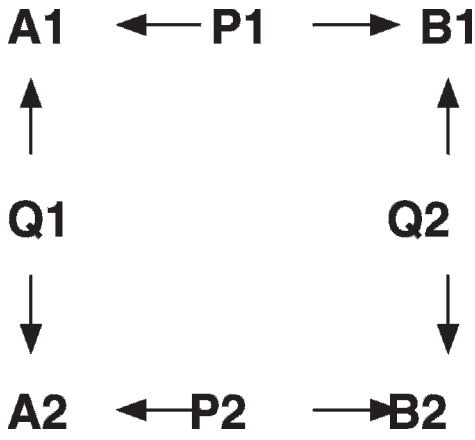

Fig. 3. All the relations learned in Experiments 1, 3, and 4. Arrows go from each sample to the stimulus that was the correct comparison in its presence.

samples. On Q–1 trials, selections of A1 in the presence of sample Q1 and selections of B1 in the presence of sample Q2 were reinforced. In conditional discrimination Q–2, selections of A2 in the presence of sample Q1 and selections of B2 in the presence of sample Q2 were reinforced.

After training these four discriminations, participants were presented a series of probe trials, on which compound samples consisting of one of each of the four possible combinations of the P and Q stimuli and all four comparison stimuli were presented. These compound-sample probes are illustrated in the bottom panel of Figure 2. On probe trials, responses were considered correct if the participant selected the comparison that was correct on both the previous P and Q

Table 1

Procedure overview and results of Experiment 1.

Phase	Conditional Discrimination	Conse-quences	Trials	Results						
				SOLA	EVIA	TAMA	DIEO	DESA 1	DESA 2	DESA 3
1	P-A (p)	Yes	8	8/8	8/8	13/17	9/10	12/13	8/8	8/8
2	P-A	Yes	8	8/8	8/8	8/8	8/8	11/12	8/8	8/8
3	P-B (p)	Yes	8	8/8	8/8	8/8	8/8	8/8	8/8	8/8
4	P-B	Yes	8	8/8	8/8	8/8	8/8	8/8	8/8	8/8
5	P-A, P-B	Yes	8	8/8	8/8	8/8	8/8	8/8	8/8	8/8
6	Q-1 (p)	Yes	8	8/8	8/8	17/19	10/11	8/8	8/8	8/8
7	Q-1	Yes	8	8/8	8/8	8/8	9/10	8/8	8/8	8/8
8	Q-2 (p)	Yes	8	8/8	8/8	8/8	8/8	8/8	8/8	8/8
9	Q-2	Yes	8	8/8	8/8	8/8	8/8	8/8	8/8	8/8
10	Q-1, Q-2	Yes	8	8/8	8/8	12/17	10/11	8/8	8/8	8/8
11	P-A, P-B, Q-1, Q-2	Yes	16	16/16	29/31	29/32	40/43	16/16	16/16	16/16
12	P-A, P-B, Q-1, Q-2	No	16	16/16	16/16	16/16	27/28	16/16	17/18	16/16
Final Probe	Compound-Sample	No	24*	24/24	23/24	23/24	23/24	11/24	8/24	12/24

Note. The first four columns show the order, the specific trained or tested discriminations (a ''p'' indicates that the prompt procedure was used), whether differential consequences were used, and the number of consecutive correct trials required to advance to the next phase. Asterisks indicate number of trials that were presented, regardless of performance. The last six columns show participants' performance (correct responses/trials) in each phase. Numbers under DESA indicate session number.

conditional discriminations. Thus, in the presence of compound samples P1 and Q1, selections of comparison A1 were considered correct, because selections of A1 had previously been reinforced in the presence of individual samples P1 and Q1. For similar reasons, selections of B1 in the presence of compound sample P1Q2, selections of A2 in the presence of compound sample P2Q1, and selections of B2 in the presence of compound sample P2Q2 were also considered correct.

Participants received one to three 10-17 min sessions. Once in the room, participants sat in front of the computer and the experimenter read the following instructions in Spanish to the participant:

> Several figures are going to appear at the center of the screen. Other figures are going to appear at the four corners of the screen. You have to select some of the figures of the corners depending on the figure that appears at the center. Initially, the figure that you have to select will be indicated. ''If this is here'' will be written on the figure at the center, and ''pick this'' will appear on the figure in the corner that you have to select. Later on, this prompt will not be presented. If you select the correct figure, a form will appear on the screen and music will play. If you fail, the screen will be black for a while. This will happen in the training phases. In probe trials, you will not be told whether you have selected the correct figure or not, but remember that there will always be a correct figure. Correct responses during the probe trials will depend upon what you have learned during the training phases; for that reason, you have to pay attention. Okay?

After reading the instructions, the experimenter prepared the computer for the beginning of the session and left the room. On training trials, a sample stimulus appeared at the center of the screen. Then, the participants made an observing response, which consisted of placing the cursor on the stimulus with the mouse and pressing the mouse key. After this, the sample remained and two comparison stimuli appeared on the screen. Participants used the mouse to select one of the comparisons. The computer delivered the consequences, paused for the intertrial interval and presented the next trial. Probe trials were identical, with the exception that (a) the compound samples were presented with the Q stimulus on top of the P stimulus at the center of the screen, (b) there were four comparisons, each of which was randomly assigned to one corner of the screen, and (c) there were no differential consequences.

Detailed description of the phases. A session consisted of a succession of 12 training phases and the probe phase (see Table 1). The computer presented trials of a phase until the participant made 8 or 16 correct consec-

utive responses (depending on the phase, see below). After criterion was met, the program automatically moved to the next phase.

Teaching of single-sample conditional discriminations P–A and P–B. Participants were taught conditional discrimination P–A in Phases 1 and 2. In Phase 1, a prompt was presented on each of the first four trials. During prompt trials, the clause ''If this is here'' appeared over the sample, and the clause ''Pick this'' appeared over the correct comparison. After the participant reached the criterion of eight consecutive correct responses, Phase 2 started. Phase 2 was identical to Phase 1, except that the prompt was not used. Conditional discrimination P–B was taught in Phases 3 and 4, in an identical manner to conditional discrimination P–A. After reaching criterion in Phase 4, trials of conditional discriminations P–A and P–B were randomly intermixed in Phase 5, with the restriction that the computer presented three trials of P–A and three trials of P–B every six trials. The criterion to advance to the next phase was eight consecutive correct responses.

Teaching conditional discriminations Q–1 and Q–2. Participants were trained on conditional discriminations Q–1 and Q–2 in Phases 6 to 10, just as they were on conditional discriminations P–A and P–B (see Table 1 for details).

Review of conditional discriminations P–A, P–B, Q–1, and Q–2. In Phase 11, trials from conditional discriminations P–A, P–B, Q–1, and Q–2 were intermixed. The order of trials was random with the exception that each of the eight trial types was presented within every eight-trial block. All responses received differential consequences. The criterion for advancing to the next phase was 16 consecutive correct responses.

Elimination of differential consequences. In preparation for the probe trials, Phase 12 repeated Phase 11, except that there were no differential consequences.

Probes with compound samples. Participants received 24 trials with the compound samples, regardless of performance. The four compound samples were presented randomly, with the restriction that each compound sample appeared once every four trials. Comparisons A1, A2, B1, and B2 appeared at random locations across trials, with the restriction that each stimulus appeared six times in each location. Also, the correct comparison appeared at random locations, with the restriction that each correct stimulus appeared six times in each location. There were no prompts or differential consequences. The criterion for the emergence of common control by compound samples was 22 or more correct responses.

Results and Discussion

Results are presented in Table 1. All 5 participants learned the four single-sample conditional discriminations with very few errors. SOLA learned the discriminations without errors; TAMA, who required the most training, made 14 errors. During the compound-sample probe session, SOLA responded correctly on all 24 trials. EVIA, DIEO, and TAMA responded correctly on 23 of 24 probe trials. DESA responded correctly on only 11 of 24 trials, and, for that reason, she repeated the entire procedure twice in two additional sessions. She responded correctly on all but one trial during the review of the four single-sample conditional discriminations, but during the two probe sessions, she was correct on only 8 and 12 of the 24 trials, respectively. Her performance was above chance level, which is 6 correct out of 24 trials, given that there were four comparisons. To further analyze DESA's responses, her responses on each of the probe trials are presented in Table 2. On about half the trials, she selected the correct comparison, which had been controlled by the two sample stimuli during initial training. On the remaining trials, she selected a comparison that had been controlled by one of the two sample stimuli during initial training. She never selected the comparison that had not been controlled by at least one of the two sample stimuli during initial training.

These results replicate those of our previous research (Alonso-Álvarez & Pérez-González, 2006, Study 2). The fact that the compound conditional discrimination emerged after single stimulus sample discrimination teaching raises the question: Would training with compound samples result in the emergence of control by single-stimulus samples in two comparison conditional-discrimination probes? As the single-sample and the compound-sample conditional discriminations are of a different type, teaching and testing in the reverse order as in Experiment 1 would cast different results and, therefore, clarify whether the learning processes are alike or different. That is the question addressed in Experiment 2.

Table 2

Correct responses by DESA in the probes of Experiment 1.

	Discrimination																
	P1 Q1				P1 Q2				P2 Q1				P2 Q2				
	A1 + +	A2 +	B1 +	B2	A1 +	A2	B1 + +	B2 +	A1	A2 + +	B1	B2 +	A1	A2 +	B1 +	B2 + +	Total Correct
Session 1																	
	1	1	1	0	1	0	*0*	2	2	*0*	0	1	0	1	0	*2*	3
	1	0	2	0	0	0	*2*	1	0	*2*	0	1	0	0	0	*3*	8
Session 2																	
	0	1	2	0	0	0	*1*	2	0	*1*	0	2	0	0	1	*2*	4
	0	0	3	0	1	0	*1*	1	1	*1*	0	1	0	1	0	*2*	4
Session 3																	
	2	1	0	0	1	0	*2*	0	0	*2*	0	1	0	0	0	*3*	9
	0	3	0	0	3	0	*0*	0	2	*1*	0	0	0	1	0	*2*	3

Note. The columns of each discrimination indicate the sample stimuli. The four comparisons present in each trial appear below each sample compound. The plus signs in the upper row indicate the comparisons for which selection was reinforced in the presence of P1 or P2 during training; the plus signs in the lower row indicate the comparisons for which selection was reinforced in the presence of Q1 or Q2 during training. The figures in the two rows corresponding to each session indicate performance in the first 12-trial and the last 12-trial halves of the probe. Correct responses are in italics.

EXPERIMENT 2

In Experiment 2, the compound-sample conditional discrimination that was tested in Experiment 1 was taught, and then participants were tested for the emergence of the four single-sample conditional discriminations that were taught in Experiment 1. That is, participants were taught to select A1 in the presence of compound sample P1Q1; to select A2 in the presence of compound sample P2Q1; to select B1 in the presence of compound sample P1Q2; and to select B2 in the presence of P2Q2. The question was whether participants would select A1 and not A2 when P1 appeared as the sample; A2 and not A1 when P2 appeared as the sample; B1 and not B2 when P1 appeared as the sample; B2 and not B1 when P2 appeared as the sample; A1 and not B1 when Q1 appeared as the sample; B1 and not A1 when Q2 appeared as the sample; A2 and not B2 when Q1 appeared as the sample; and B2 and not A2 when Q2 appeared as the sample.

Method

Participants

Participants were 2 female (NIRA and TAFA) and 2 male (GAPO and DARO) Spanish-speaking undergraduate students from the School of Psychology at the University of Oviedo. All of the participants were acquaintances of the second author and were between 21 and 23 years of age. They received no compensation for participating in the study and were unfamiliar with stimulus equivalence research.

Materials and Procedure

Stimuli and discriminations. Except for the variations that are specified below, the stimuli and the procedure were identical to those of Experiment 1.

Phases. Initially, we taught the compound-sample conditional discrimination using a 12-phase training program. Finally, we probed the four single-sample conditional discriminations P–A, P–B, Q–1, and Q–2. The discriminations appear in Figure 2; an overview of the phases appears in Table 3.

Phases 1 and 2: Training the P1Q1–A1 relation. Compound stimulus P1Q1 formed the sample in all trials. Stimuli A1, A2, B1, and B2 served as comparisons in all trials. They appeared at random locations across trials. In Phase 1, we used the prompting procedure during the first four trials. Selections of comparison A1 were reinforced. After the participant reached the criterion of eight consecutive correct responses, Phase 2 started. Phase 2 was identical to Phase 1, except that the prompt was not used.

Table 3

Procedure overview and results of Experiment 2.

Phase	Discrimination	Consequences	Trials	Results			
				NIRA	GAPO	TAFA	DARO
1	P1Q1-A1 (p)	Yes	8	8/8	8/8	8/8	11/14
2	P1Q1-A1	Yes	8	8/8	8/8	8/8	14/16
3	P2Q1-A2 (p)	Yes	8	8/8	8/8	8/8	8/8
4	P2Q1-A2	Yes	8	8/8	8/8	8/8	8/8
5	P1Q1-A1, P2Q1-A2	Yes	8	8/8	8/8	12/15	8/8
6	P1Q2-B1 (p)	Yes	8	8/8	8/8	8/8	8/8
7	P1Q2-B1	Yes	8	8/8	8/8	8/8	8/8
8	P2Q2-B2 (p)	Yes	8	8/8	8/8	8/8	13/14
9	P2Q2-B2	Yes	8	8/8	8/8	8/8	8/8
10	P1Q2-B1, P2Q2-B2	Yes	8	8/8	8/8	8/8	18/21
11	Compound-Sample	Yes	16	16/16	16/16	28/29	41/49
12	Compound-Sample	No	16	16/16	16/16	16/16	19/21
Final Probe	P-A, P-B, Q-1, Q-2	No	24*	24/24	24/24	24/24	23/24

Note. The first four columns show the order, the discriminations (a ''p'' indicates that the prompt procedure was used), whether the differential consequences were used, and the number of trials advancing to the next phase; numbers with no asterisk indicate criterion of correct consecutive responses to end the phase; asterisks indicate number of trials that were presented, regardless of the performance. The last four columns show the performance (correct responses/trials) of participants in each phase.

Phases 3 and 4: Training the P2Q1–A2 relation. Participants were taught to select comparison A2 in the presence of compound sample P2Q1. All the procedures were identical to those used in teaching the P1Q1–A1 relation in Phases 1 and 2, except that (a) stimulus P2Q1 formed the sample in all trials (instead of P1Q1), (b) selections of comparison A2 were reinforced.

Phase 5: Mixing the P1Q1–A1 and the P2Q1–A2 relations. The two relations taught in Phases 1 to 4 were randomly intermixed in Phase 5, with the restriction that two trials of the P1Q1–A1 relation and two trials of the P2Q1–A2 relation were presented every four trials. The prompt was not used and the criterion for advancing to Phase 6 was eight consecutive correct responses.

Phases 6 and 7: Training the P1Q2–B1 relation. Participants were taught to select comparison B1 in the presence of compound sample P1Q2. All the procedures were identical to those used in training the P1Q1–A1 relation in Phases 1 and 2, except that (a) compound sample P1Q2 was presented on all trials, (b) selections of comparison B1 were reinforced.

Phases 8 and 9: Training the P2Q2–B2 relation. Participants were taught to select comparison B2 in the presence of compound sample P2Q2. All the procedures were identical to those used in training the P1Q1–A1 relation in Phases 1 and 2, except that (a) compound sample P2Q2 was presented on all trials, (b) selections of comparison B2 were reinforced.

Phase 10: Mixing the P1Q2–B1 and the P2Q2–B2 relations. The two relations taught in Phases 6 to 9 were randomly intermixed in Phase 10, with the restriction that two trials of the P1Q2–B1 relation and two trials of the P2Q2–B2 relation were presented every four trials. The prompt was not used and the criterion for advancing to Phase 11 was to make eight consecutive correct responses.

Phases 11 and 12: Mixing all relations and elimination of differential consequences. The four relations presented in Phases 5 and 10 were randomly intermixed in Phase 11, with the restriction that two trials of the four relations (P1Q1–A1, P2Q1–A2, P1Q2–B1, and P2Q2–B2) were presented twice in every eight trials. Comparison stimuli appeared at random locations. The correct stimulus appeared at random locations across trials. Differential consequences were provided. The criterion to advance to Phase 12 was 16 consecutive correct responses. Phase 12 was identical to Phase 11, except that there were no differential consequences.

Probe of the single-sample conditional discriminations. The probe for single-sample conditional discriminations consisted of 24 trials presented without differential consequences. Six trials from each single-sample conditional

discrimination (P–A, P–B, Q–1, and Q–2) were presented during the probe session. That is, six trials were presented in which either P1 or P2 appeared as the sample and A1 and A2 as comparisons; six trials in which either P1 or P2 was presented as the sample and B1 and B2 as comparisons; six trials in which either Q1 or Q2 was presented as the sample and A1 and B1 as comparisons; and six trials in which either Q1 or Q2 were presented as the sample and A2 and B2 as comparisons. Presentation of the trials was random with the restriction that each sample appeared once every four trials. The comparisons appeared at random locations. The correct comparison also appeared at random locations. The comparison that was considered correct on a given trial was the comparison whose selection was reinforced in Experiment 1. For example, note that the selection of A1 had been reinforced when the P1Q1 stimuli had occurred as the sample. Hence when P1 was presented as a single sample with A1 and A2 as comparisons one might expect A1 to be selected. Moreover, selection of A1 had also been reinforced when Q1 occurred as part of compound sample P1Q1. So when Q1 was presented as a sample with A1 and B1 as comparisons, A1 might once again be selected.

Results and Discussion

The results appear in Table 3. All of the participants learned the compound-sample conditional discrimination with few errors. GAPO and NIRA made no errors. TAFA and DORO made 4 and 19 errors respectively. NIRA, TAFA, and GAPO responded correctly on all single-sample conditional discrimination probe trials, whereas DARO responded correctly on all but one probe trial.

The 4 participants of Experiment 2 responded correctly during the single-sample conditional discriminations probe session, after having been taught the compound-sample conditional discrimination. These results demonstrated the single elements of the compound exercised control when presented separately. This outcome may very likely be the result of the discrimination procedure used in the initial training, because correct performance could have been possible only by discriminating each element of the compound (i.e., the correct comparison in the presence of P1–Q2 was different than in the presence of P2–Q2; hence, P1 and P2 had to be discriminated).

EXPERIMENT 3

Participant DESA failed to perform correctly on the compound-sample conditional discrimination after being taught the four single-sample conditional discriminations in Study 1. The aim of Experiment 3 was to determine whether we could develop procedures to accomplish compound control with DESA and to determine what factors might lead to such control. In a previous study, Pérez-González (1994) found that the presentation of symmetry probes of previously trained single-sample conditional discriminations facilitated the emergence of novel conditional discriminations with compound samples. Therefore, we explored whether receiving symmetry probes of the four single-sample conditional discriminations would facilitate emergence in the compound-sample conditional discrimination. Second, we explored whether learning a compound-sample conditional discrimination with a second stimulus set would evoke the emergence of compound sample control with the original stimuli. Third, we explored the effect of probing the four single-sample conditional discriminations with the second stimulus set just after reviewing the compound-sample conditional discrimination with these stimuli (just as in Experiment 2).

Method, Results, and Discussion

For ease of presentation, the procedures, results and discussion of each of the parts of Experiment 3 are described separately.

Participant

The participant was DESA, who failed to respond correctly in the probe with the compound-sample conditional discrimination in Experiment 1.

Materials and General Procedure

Except for the differences described below, we used the stimuli and procedures of Experiments 1 and 2 as well as another set of stimuli, shown in Figure 4. The experiment consisted of three parts. The first included training single-sample conditional discriminations and then probing for sample–compari-

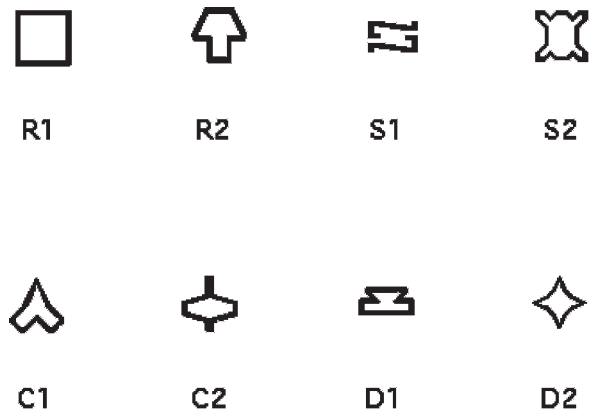

Fig. 4. Shapes used as stimuli in Experiments 3 and 4.

son symmetry. The second included teaching a compound-sample conditional discrimination with Stimulus Set 2. The third entailed probing the four single-sample conditional discriminations after compound-sample training with Stimulus Set 2.

Part 1: Probing Symmetries

Specific procedure. Part 1 consisted of nine phases plus the final probe with compound-sample conditional discrimination PQ–AB. An overview of the phases used in Part 1 appears in Table 4. Phases 1, 3, 5, and 7 were identical to the phases of Experiment 1, in which we taught single-sample conditional discriminations P–A, P–B, Q–1, and Q–2 with no prompts. Following a review of each single-sample conditional discrimination, we probed for sample–comparison symmetry for that conditional discrimination. Thus, we probed single-sample conditional discriminations A–P, B–P, 1–Q, and 2–Q in Phases 2, 4, 6, and 8. In probes for symmetrical relations, the stimuli that had been samples appeared as comparisons, and vice versa. Each symmetry probe consisted of 12 trials with no differential consequences, regardless of the performance. Each sample appeared in six trials. Comparisons appeared at random locations. The experiment consisted of two sessions. In the first, the participant received the probe with compound-sample conditional discrimination PQ–AB just after ending Phase 8. In the second session, trials of all conditional dis-

Table 4

Procedure overview and results corresponding to Part 1 of Experiment 3.

				Results	
Phase	Conditional Discrimination	Consequences	Consecutive Correct	DESA 4	DESA 5
1	P-A	Yes	8	8/8	8/8
2	A-P	No	12*	12/12	12/12
3	P-B	Yes	8	8/8	8/8
4	B-P	No	12*	12/12	12/12
5	Q-1	Yes	8	8/8	8/8
6	1-Q	No	12*	12/12	12/12
7	Q-2	Yes	8	8/8	8/8
8	2-Q	No	12*	12/12	12/12
9	P-A, P-B, Q-1, Q-2	Yes	16	–	16/16
10	P-A, P-B, Q-1, Q-2	No	16	–	22/23
Final Probe	Compound-Sample PQ-AB	No	24*	13/24	9/24

Note. The first four columns show the order, the discriminations, whether the differential consequences were used, and the number of trials necessary for advancing to the next phase; numbers with no asterisk indicate criterion of correct consecutive responses to end the phase; asterisks indicate number of trials that were presented in a probe, regardless of the performance. The last two columns show the performance (correct responses/trials) of the participant in each phase during Sessions 4 and 5.

criminations P–A, P–B, Q–1, and Q–2 were intermixed in Phases 9 and 10 before continuing to the probe. In Phase 9, four trials of each conditional discrimination appeared randomly, with the restriction that two trials from each conditional discrimination appeared every eight trials. The prompting procedure was not used and responses received differential consequences. After 16 consecutive correct responses, the program continued to Phase 10. Phase 10 was identical to Phase 9 with the exception that responses did not receive differential consequences. After 16 consecutive correct responses, the final compound-sample discrimination probe was presented. The probe with the compound-sample conditional discrimination PQ–AB was identical to the probe of Experiment 1.

Results and discussion. The results of Part 1 appear in Tables 4 and 6. DESA responded correctly on all conditional discrimination trials P–A, P–B, Q–1, and Q–2 as well as on the symmetry probes A–P, B–P, 1–Q, and 2–Q. In Phase 9 of Session 5, in which trials of the four conditional discriminations were intermixed with differential consequences, she responded correctly on all trials. In Phase 10, when these trials were intermixed without differential consequences, she responded correctly on all except one trial. In the probes for the compound-sample conditional discrimination PQ–AB of Sessions 4 and 5, however, she only responded correctly on about half of the trials (she made 13 and 9 correct responses out of 24); DESA responded to the correct Q sample (either Q1 or Q2) on 20 of 24 trials in Session 4 and on 22 out of 24 trials in Session 5 (see Table 6). Few correct responses, however, occurred in the presence of the P sample. She responded correctly on all review single-sample conditional discrimination trials, P–A, P–B, Q–1, and Q–2. Thus, probing symmetries did not significantly alter the participant's performance on the probe with the compound-sample conditional discrimination.

Part 2:Training a Compound-Sample Conditional Discrimination with Stimulus Set 2

Specific procedure. Because DESA did not perform correctly on the compound-sample discrimination, we considered the possibility that giving her reinforced experience with a new compound-sample discrimination (RS–CD) would result in correct responding to the original compound-sample discrimination (PQ–AB). Part 2 consisted of teaching a compound-sample conditional discrimination with a new set of stimuli (RS–CD), followed by a review of the single-sample conditional discriminations P–A, P–B, Q–1, and Q–2, and the probe for compound-sample conditional discrimination PQ–AB (see Table 5). We taught the compound-sample conditional discrimination RS–CD exactly as we taught compound-sample conditional discrimination PQ–AB in Study 2, in 12 phases. The remainder of the session was a replication of the procedures of Experiment 1.

Results and discussion. The results of Part 2 appear in Table 5 (Sessions 6 and 7) and Table 6. In Session 6, she learned conditional discrimination RS–CD with only 12 errors. In Session 7, she made only 2 errors. In the probes of the compound-sample conditional discrimination PQ–AB, she responded correctly on around half of the trials, just as in Part 1. Comparison selection was controlled by the Q stimulus on 23 out of 24 trials of Session 6, but it was controlled by the P stimulus on about only half of the trials, just as in Part 1 (see Table 6). Comparison selection, however, was controlled by either the P or the Q stimuli (or both) in Session 7, just as it had occurred during Experiment 1. Thus, teaching a compound-sample conditional discrimination with a second stimulus set did not significantly alter the participant's performance on the probes with the compound-sample conditional discrimination (PQ–AB).

Part 3: Probing the Four Single-Sample Conditional Discriminations

Specific procedures. Because teaching a new compound-sample discrimination did not result in correct performance on the original probes for compound-sample control (PQ–AB) we decided to explore whether probing for single-sample control with the R and S stimuli would result in correct performance on the PQ–AB compound discrimination. If DESA responded correctly on the single-sample probes with the R and S stimuli, then she would demonstrate the ability to respond correctly to both single-sample procedures and compound-sample procedures. The acquisition of the two types of conditional discriminations with the same stimuli may have been a

Table 5

Procedure overview and results corresponding to Parts 2 and 3 of Experiment 3.

				Results		
Phase	Conditional Discrimination	Consequences	Trials	DESA 6	DESA 7	DESA 8
Stimuli R, S, C, & D						
1	R1S1-C1 (p)	Yes	8	8/8	8/8	8/8
2	R1S1-C1	Yes	8	8/8	8/8	8/8
3	R2S1-C2 (p)	Yes	8	8/8	14/15	8/8
4	R2S1-C2	Yes	8	10/11	8/8	8/8
5	R1S1-C1, R2S1-C1	Yes	8	17/20	8/8	8/8
6	R1S2-D1 (p)	Yes	8	8/8	8/8	8/8
7	R1S2-D1	Yes	8	8/8	8/8	8/8
8	R2S2-D2 (p)	Yes	8	8/8	8/8	8/8
9	R2S2-D2	Yes	8	8/8	8/8	8/8
10	R1S2-D1, R2S2-D2	Yes	8	12/14	8/8	8/8
11	Compound-Sample RS-CD	Yes	16	35/41	16/16	16/16
12	Compound-Sample RS-CD	No	16	16/16	31/32	16/16
Probe	R-C, R-D, S-1, S-2	No	24*	—	—	24/24
Stimuli P, Q, A & B						
1	P-A (p)	Yes	8	8/8	8/8	8/8
2	P-A	Yes	8	8/8	8/8	8/8
3	P-B (p)	Yes	8	8/8	8/8	8/8
4	P-B	Yes	8	8/8	8/8	8/8
5	P-A, P-B	Yes	8	8/8	8/8	8/8
6	Q-1 (p)	Yes	8	8/8	8/8	8/8
7	Q-1	Yes	8	8/8	8/8	8/8
8	Q-2 (p)	Yes	8	8/8	8/8	8/8
9	Q-2	Yes	8	8/8	8/8	8/8
10	Q-1, Q-2	Yes	16	16/16	16/16	16/16
11	P-A, P-B, Q-1, Q-2	Yes	16	16/16	16/16	16/16
Final Probe	Compound-Sample	No	24*	13/24	12/24	23/24

Note. The first four columns show the order, the discriminations, whether the differential consequences were used, and the number of trials for advancing to the next phase; numbers with no asterisk indicate criterion of correct consecutive responses to end the phase; asterisks indicate number of trials that were presented in a probe, regardless of the performance. The last three columns show the performance (correct responses/trials) of the participant in each phase during Sessions 6, 7, and 8.

requisite for the emergence of the compound-sample conditional discriminations.

Part 3 was the same as Part 2, with the addition of a probe for single-sample conditional discriminations R–C, R–D, S–1, and S–2 just after teaching single-sample conditional discrimination RS–CD (see Table 5). We conducted this probe exactly as we probed single-sample conditional discriminations P–A, P–B, Q–1, and Q–2 in Study 2. Therefore, the first portion of Part 3 was a replication of Experiment 2, with different stimuli. After this probe session, the four single-sample discriminations of Experiment 1 were reviewed. Finally, DESA was again presented the probe session for the initial compound-sample discrimination (PQ–AB).

Results and discussion. The results of Part 3 appear in Tables 5 (Session 8) and 6. In Session 8, DESA reviewed conditional discrimination RS–CD. She responded correctly on all trials. On the probes with single-sample conditional discriminations R–C, R–D, S–1, S–2, she also responded correctly. Thereafter, she responded correctly on all trials of the reviewed single-sample conditional discriminations P–A, P–B, Q–1, and Q–2. On the probes of the compound-sample conditional discrimination PQ–AB, she responded correctly on 23 out of 24 trials. She made one error in the first 12 trials, and she responded correctly on all of the last 12 trials (see Table 6). Thus, the participant finally showed perfect performance with the probed compound-sample conditional discrimination after having learned the four single-sample conditional discriminations. Her final performance replicated the performance of the other 4 participants of Study 1 and the 2 participants in the Alonso-Álvarez and Pérez-González (2006) study. She responded correctly, however, only after having compound-

Table 6

Correct responses of DESA in the probes of Experiment 3. (See note to Table 2)

	Discrimination																
	P1 Q1				P1 Q2				P2 Q1				P2 Q2				
Session	A1 + +	A2 +	B1 +	B2	A1 +	A2	B1 + +	B2 +	A1 +	A2 + +	B1	B2 +	A1	A2 +	B1 +	B2 + +	Total Correct
Part 1																	
4	*2*	1	0	0	1	0	*1*	1	1	*2*	0	0	0	1	0	*2*	7
	1	2	0	0	1	0	*1*	1	1	*2*	0	0	0	1	0	*2*	6
5	*0*	3	0	0	1	0	*2*	0	1	*2*	0	0	0	0	1	*2*	6
	0	3	0	0	0	0	*1*	2	3	*0*	0	0	0	1	0	*2*	3
Part 2																	
6	*2*	1	0	0	0	0	*1*	2	1	*2*	0	0	0	0	2	*1*	6
	1	2	0	0	1	0	*1*	1	1	*2*	0	0	0	0	0	*3*	7
7	*1*	2	0	0	1	0	*2*	0	1	*1*	0	1	0	2	0	*1*	5
	3	0	0	0	0	0	*2*	1	1	*1*	0	1	0	1	1	*1*	7
Part 3																	
8	*3*	0	0	0	0	0	*2*	1	0	*3*	0	0	0	0	0	*3*	11
	3	0	0	0	0	0	*3*	0	0	*3*	0	0	0	0	0	*3*	12

sample conditional discrimination training with Stimulus Set 2, and being probed for single-sample conditional discriminations with that set.

EXPERIMENT 4

Whereas the procedures of Experiment 3 were sufficient to result in transfer from the four single-sample discriminations to the compound-sample discrimination, it is unlikely that all three manipulations were necessary for the emergence of the compound-sample conditional discrimination. In fact, it is unlikely that tests for symmetry had any function in bringing about correct performance on the PQ–AB discrimination. In Experiment 4 we studied with experimentally naïve participants the effects of teaching the compound-sample conditional discriminations with a second stimulus set. However, in order to minimize the chance that all participants would demonstrate emergence of compound-sample conditional discriminations on the PQ–AB probes, we omitted the intermixed four single-sample discrimination training trials before probing for compound-sample emergence. Study 1 of Alonso-Álvarez and Pérez-González's (2006) found that omitting these trials interfered with the emergence of compound-sample control in 2 participants.

Method

Participants

The 5 participants were 2 males (DALVO and MAFRO) and 3 females (NOROA, DANAA, and VANSA) ranging from 16 to 21 years of age. All 5 were students in high school or college who were recruited through personal contacts and received about 10 euros (about 13 US dollars) per hour for their participation. They were not informed of the goal or the nature of the experiment before its completion.

Materials, Stimuli, and Discriminations

The stimuli and the discriminations were the same as in Experiments 1 and 3, shown in Figures 1 and 2.

Procedure

Overview. The participants received repeated cycles consisting of teaching (first session) or reviewing (subsequent sessions) the single-sample conditional discriminations P–A, P–B, Q–1, and Q–2 and probing the conditional discrimination PQ–AB with Stimulus Set 1. After three, five, or seven cycles, the participants who did not demonstrate the emergence of the compound-sample conditional discrimination received a new training cycle that consisted of teaching the compound-sample

Table 7

Procedure overview and results corresponding to Participants DALVO, NOROA, and DANAA of Experiment 4. (See Note to Table 1.)

				Results		
Phase	Conditional Discrimination	Consequences	Trials	Session 1	Session 2	Session 3
Participant DALVO						
1	P-A	Yes	6	6/6	6/7	6/6
2	P-B	Yes	6	6/7	6/6	6/6
3	Q-1	Yes	6	6/7	6/6	6/6
4	Q-2	Yes	6	6/7	7/9	6/6
Final Probe	Compound-Sample	No	24*	10/24	20/24	24/24
Participant NOROA						
1	P-A	Yes	6	6/7	6/6	6/6
2	P-B	Yes	6	6/7	6/6	6/6
3	Q-1	Yes	6	6/6	6/6	6/6
4	Q-2	Yes	6	9/12	6/7	6/7
Final Probe	Compound-Sample	No	24*	3/24	11/24	24/24
Participant DANAA						
1	P-A	Yes	6	7/9	6/6	6/6
2	P-B	Yes	6	6/8	6/6	6/6
3	Q-1	Yes	6	9/11	6/6	6/6
4	Q-2	Yes	6	6/7	6/6	6/6
Final Probe	Compound-Sample	No	24*	8/24	7/24	24/24

Note. The last three columns show the performance (correct responses/trials) of the participant in each phase during Sessions 1 to 3.

conditional discrimination with Stimulus Set 2 (RS–CD), reviewing the single-sample conditional discriminations from Set 1, and then receiving the probe of the compound-sample conditional discrimination from Set 1 (PQ–AB). Three participants performed correctly on the PQ–AB compound discrimination after three cycles. Two participants did not. So compound-sample training was introduced with Stimulus Set 2 after five cycles for one participant and after seven cycles for the other participant. This strategy resulted in a multiple-baseline design across 2 participants, which allowed for determining the effects of learning the compound-sample conditional discrimination with Stimulus Set 2 on the emergence of the compound-sample - discrimination with Stimulus Set 1.

Teaching conditional discriminations P–A, P–B, Q–1, and Q–2. As noted above we used the procedures that had failed to produce the emergence of compound-sample discriminations in Study 1 of Alonso-Álvarez and Pérez-González (2006). Thus, each conditional discrimination P–A, P–B, Q–1, and Q–2 was taught in a separate phase. In each phase, the computer presented conditional discrimination trials until the participant made six correct consecutive responses. After this criterion was met, the computer moved on to the next phase.

With the exception of the procedure to teach the single-sample conditional discriminations, the procedures were identical to those of Experiments 1 and 3. The procedure used to teach the compound-sample conditional discrimination with stimuli R, S, C, and D (Stimulus Set 2) was identical to that of Experiment 3.

Results

The results for DALVO, NOROA and DANAA, shown in Table 7, will be presented first, since they did not require training with the compound-sample discriminations with Stimulus Set 2 prior to showing the emergence of compound-sample conditional discrimination PQ–AB after learning the four single-sample conditional discriminations P–A, P–B, Q–1, and Q–2. Each of these participants were first given training on the four single-sample discriminations and then probed for compound-sample control. They were correct on only 3 to 10 trials. The sequence of single-sample training and compound-sample probes was then repeated. During this second cycle DALVO was correct on 20 of 24 compound-sample probe trials, whereas NOROA and

DANAA were correct on 11 and 7 trials respectively. The sequence of single-sample training and compound-sample probing was again repeated. During this cycle all 3 participants were correct on all 24 compound-sample probe trials.

MAFRO and VANSA were also given training with the four single-sample conditional discriminations followed by the probes for the compound-sample conditional discrimination PQ–AB. Both students made numerous errors during training on the four single-sample discriminations and performed poorly on the compound-sample probe. MAFRO was correct on 12 of 24 trials (See Table 8). VANSA was correct on 10 of 24 trials (See Table 9). As was the case for the other three participants, MAFRO and VANSA were given two more cycles of single-sample training followed by compound-sample probes. Neither participant was correct on more than 14 trials.

Participant MAFRO received two additional sessions reviewing the single-sample conditional discriminations and probing the compound-sample conditional discrimination with Stimulus Set 1; thus, he received a total of five sessions. In these probes for the compound-sample conditional discrimination he responded correctly on 12 and 13 trials. Thereafter, he was taught the compound-sample conditional discrimination with Stimulus Set 2 (see Table 8). He did not learn this conditional discrimination within 60 trials in Phase 12. For that reason, we repeated the entire procedure. During the second training session, he met criterion for the compound-sample conditional discrimination with Stimulus Set 2. In the probe for the emergence of the compound-sample conditional discrimination with Stimulus Set 1, he responded correctly on 14 trials. The complete cycle of Session 6 was repeated during Sessions 7 to 9 (reviewing the compound-sample conditional discrimination with Stimulus Set 2, reviewing the single-sample conditional discriminations, and then receiving the probe of the compound-sample conditional discrimination). He made few errors on the compound-sample conditional discrimination with Stimulus Set 2. In the probe for the emergence of the compound-sample conditional discrimination with Stimulus Set 1, he responded with an increased number of correct responses: In Sessions 7 and 8, he responded correctly on 17 and 19 trials, respectively. Finally, in Session 9, he responded correctly on 23 out of 24 trials.

Participant VANSA received a total of seven sessions prior to receiving compound-sample training with Stimulus Set 2. During the seven probes prior to being given compound-sample training with Stimulus Set 2, she responded correctly on 8 to 16 trials during probes for the emergence of compound-sample control with Set 1 stimuli (see Table 9). During session 8, she was taught the compound-sample conditional discrimination with Stimulus Set 2. She learned this conditional discrimination with few errors. Thereafter, the four single-sample conditional discriminations were reviewed and she received the probe for the emergence of the compound-sample conditional discrimination with Stimulus Set 1. She responded correctly on 23 out of 24 trials.

Discussion

All 5 participants demonstrated the emergence of the compound-sample conditional discriminations. Three participants demonstrated the emergence after three cycles of learning and reviewing the four single-sample conditional discriminations and the final probe. These results replicated those of the 4 participants of Experiment 1 and the 2 participants of Experiment 2 of our previous research (Alonso-Álvarez & Pérez-González, 2006) in that learning the four single-sample conditional discriminations is sufficient for some persons to demonstrate the emergence of the compound-sample conditional discrimination.

The more interesting results of the present experiment were those for MARFRO and VANSA, because they provide data about the factors involved in the emergence of the compound-sample conditional discriminations. They did not demonstrate this discrimination even after five and seven cycles of the single-sample conditional discriminations. In contrast, they demonstrated the emergence of the initial compound-sample conditional discrimination (PQ–AB) after compound-sample training with a new stimulus set (RS–CD). These results suggest that experience with a compound-sample conditional discrimination is necessary for the emergence of the compound-sample conditional discrimination after single-sample training for some participants.

Table 8

Procedure overview and results corresponding to Participants MAFRO of Experiment 4. (See Note to Table 1.)

Phase	Conditional Discrimination	Consequences	Trials
1	R1S1-C1 (p)	Yes	8
2	R1S1-C1	Yes	8
3	R2S1-C2 (p)	Yes	8
4	R2S1-C2	Yes	8
5	R1S1-C1, R2S1-C1	Yes	8
6	R1S2-D1 (p)	Yes	8
7	R1S2-D1	Yes	8
8	R2S2-D2 (p)	Yes	8
9	R2S2-D2	Yes	8
10	R1S2-D1, R2S2-D2	Yes	8
11	Compound-Sample RS-CD	Yes	16
12	Compound-Sample RS-CD	No	16
1	P-A	Yes	6
2	P-B	Yes	6
3	Q-1	Yes	6
4	Q-2	Yes	6
Final Probe	Compound-Sample PQ-AB	No	24*

Note. The last nine columns show the performance (correct responses/trials) of the participant in each phase during Sessions 1 to 9.

The results for Participants MAFRO and VANSA support the previously stated conjecture that symmetry probes of the single-sample conditional discriminations used with DESA in Experiment 3 were not necessary for DESA to demonstrate the emergence of the compound-sample conditional discrimination. Moreover, the fact that MAFRO and VANSA performed correctly on the compound-sample discrimination (PQ–AB) after compound-sample training with Stimulus Set 2 (RS–CD) suggests that probes for single-sample discriminations

Table 9

Procedure overview and results corresponding to Participant VANSA of Experiment 4. (See Note to Table 1.)

Phase	Conditional Discrimination	Consequences	Trials
1	R1S1-C1 (p)	Yes	8
2	R1S1-C1	Yes	8
3	R2S1-C2 (p)	Yes	8
4	R2S1-C2	Yes	8
5	R1S1-C1, R2S1-C1	Yes	8
6	R1S2-D1 (p)	Yes	8
7	R1S2-D1	Yes	8
8	R2S2-D2 (p)	Yes	8
9	R2S2-D2	Yes	8
10	R1S2-D1, R2S2-D2	Yes	8
11	Compound-Sample RS-CD	Yes	16
12	Compound-Sample RS-CD	No	16
1	P-A	Yes	6
2	P-B	Yes	6
3	Q-1	Yes	6
4	Q-2	Yes	6
Final Probe	Compound-Sample PQ-AB	No	24*

Note. The last eight columns show the performance (correct responses/trials) of the participant in each phase during Sessions 1 to 8.

Table 8
(Extended)

Results (Session)									
1	2	3	4	5	6 (1)	6 (2)	7	8	9
					8/8	8/8	8/8	8/8	8/8
					8/8	8/8	8/8	8/8	8/8
					8/8	8/8	8/8	8/8	8/8
					8/8	8/8	8/8	8/8	8/8
					8/8	8/8	8/8	8/8	8/8
					8/8	14/15	12/13	8/8	8/8
					11/12	8/8	8/8	8/8	8/8
					8/8	12/13	8/8	8/8	8/8
					8/8	8/8	8/8	8/8	8/8
					31/48	11/14	14/16	10/11	8/8
					36/60	56/60	16/16	16/16	16/16
					49/60	16/16	16/16	16/16	16/16
7/9	6/6	6/6	6/6	6/6		6/6	6/6	6/6	6/6
9/13	6/6	6/6	6/6	6/6		6/7	6/6	6/6	6/6
16/23	6/7	7/8	6/6	6/6		6/6	6/6	11/12	6/6
14/19	6/8	6/7	6/6	6/6		8/9	9/10	7/8	6/6
12/24	10/24	11/24	13/24	12/24		14/24	17/24	19/24	23/24

might not have been necessary for DESA if she had not previously been probed for symmetry.

GENERAL DISCUSSION

Four participants responded correctly on the probes for compound-sample conditional discrimination in Experiment 1. The one participant who did not respond correctly during the probes in Experiment 1 responded correctly on the last probe conducted in Experiment 3. Moreover, all 5 participants of Experiment 4 responded correctly on the probes. Thus, all 10 participants eventually showed transfer from

Table 9
(Extended)

Results (Session)							
1	2	3	4	5	6	7	8
							8/8
							8/8
							8/8
							8/8
							9/10
							8/8
							8/8
							8/8
							14/15
							10/13
							30/31
							25/27
8/10	6/7	6/6	6/6	6/6	6/6	6/6	6/6
11/18	10/12	6/6	6/6	13/15	6/6	6/6	6/7
10/16	6/6	6/7	6/6	6/6	6/6	6/6	6/6
7/9	6/8	7/10	15/20	6/7	13/15	6/6	6/6
10/24	10/24	14/24	16/24	7/24	16/24	8/24	23/24

single-sample discrimination training to compound-sample discrimination probes. These results indicate that, after people learn conditional discriminations in which single stimuli function as samples to control comparison selections, two stimuli presented as a compound sample may control selections of the comparisons that had been selected in the presence of both sample stimuli. These results replicated the results of 2 of the participants in Study 2 of Alonso-Álvarez & Pérez-González (2006). The present results also extend the previous ones by indicating that additional training of the conditional discriminations with novel stimuli may be involved in the emergence of these relations.

The Emergence of the Single-Sample Conditional Discriminations

The present research also demonstrated the emergence of four single-sample conditional discriminations after training on a single compound-sample discrimination. This near perfect performance on the four single-sample discriminations is a novel finding that merits some discussion. The virtually perfect performance on the single-sample discriminations demonstrated by the participants may have been a function of the type of compound stimuli used. The compound stimuli of this research consisted of two distinct forms. As a result, it could be argued that, after learning a compound discrimination (e.g., P1Q1–A1), either one element of the compound (either form P1 or form Q1) or the combination of the two stimuli could control comparison selection. If, however, only one stimulus controlled responding, then correct responding on the probes would not have been possible. For example, if P1 alone controlled selections of A1, there was no way to respond in the Q-1 conditional discriminations with sample Q1. In order to avoid this restricted control, it was necessary that each element of the compound-samples was discriminated. Stromer and Mackay (1990; also Stromer & Stromer, 1990a, 1990b) solved this problem of restricted control in compound conditional discriminations with a different preparation. They used a delayed-matching-to-sample procedure and presented two comparisons on each trial. On some trials, one comparison was identical to one element of the compound sample; on other trials, another comparison was identical to the other element of the compound. Thus, the two stimuli gained control over responding. The procedure used in the present research shows an alternative procedure for teaching control by each element of the compound if the elements are discrete forms.

Stimulus Relations Established in the Present Study

How do the present findings relate to other findings and theories? According to Sidman's (1994; see also Mackay, Wilkinson, Rosenquist, & Farrell, 2003) concept of intersecting equivalence classes, perhaps the A and B stimuli participated simultaneously in two independent classes. In effect, the P–A and P–B conditional discriminations formed the classes A1–P1–B1 and A2–P2–B2, and the Q–1 and Q–2 teaching formed the classes A1–Q1–A2 and B1–Q2–B2. Because the two class partitions are independent, any test involving the P and Q stimuli would not indicate class merger. However, when P1 and Q1 are presented as a compound, A1 would be chosen because it intersects the two separate classes containing these stimuli—P1 and Q1 do *not* participate in a single class. DESA's results, however, suggest the possibility that symmetry probes obstruct the emergence of the compound-sample conditional discriminations. If these results are replicated in further studies, they would challenge the hypothesis based in classes, because symmetry probes are probes that define equivalence classes.

Alternatively, perhaps the compound-sample effects could be seen as evidence for the establishment of four separable compounds (as defined by Stromer et al., 1993): P1–Q1–A1, P1–Q2–B1, P2–Q1–A2, and P2–Q2–B2. Thus, if any two stimuli from a given compound are present, the third element would be the chosen stimulus. Participants of Experiment 2 could have learned the separable compounds when they learned the compound-sample conditional discriminations; thereafter, in the single-sample conditional discrimination probes, they selected the comparison that completed the separable compound sample. The interpretation based on compounds, however, is difficult to apply to Experiments 1, 3, and 4, where participants learned single-sample conditional discriminations, because they learned relations between pairs of stimuli. Hence, the performance of

the compound-sample conditional discrimination could not depend upon previously established compounds. Instead, in order to maintain an account based on compounds, it is necessary to assume that the compounds were formed at the time of the probes or that they formed upon result of learning several two-stimuli compounds. These assumptions do not seem parsimonious.

In considering the separable compound interpretation, however, it is important to recognize that it may undermine the current study as a model of the type of verbal behavior suggested in the introduction. For example, if participants were presented with A1 and Q1 as a compound sample, they should choose P1. This ''separability'' does not seem to parallel the natural-language example outlined earlier, because the question, ''name a French writer?'' may well generate the response ''Balzac,'' for instance, but the question, ''name a French Balzac'' would hardly generate the response ''writer.''

According to Relational Frame Theory (RFT), the relations between the stimuli in the present research may be hierarchical (e.g., Hayes, Fox, et al., 2001). Balzac is contained in the categories of both French and writer, but that relation is hierarchical because neither French nor writer is contained in the category Balzac. Even though the results of the present study are consistent with this hypothesis, we did not make the crucial test that could empirically confirm or deny if the relations among the stimuli were hierarchical. Further research should address this question.

Another assumption of the RFT is that learning relational frames is necessary to further show emergence performances with these frames. Several participants of the present research needed to learn, at least, the frame of the compound-sample conditional discrimination. The remaining participants did not. This performance suggests that learning relational frames facilitates this type of emergent performance or even that it can be necessary at some stages of learning these verbal relations. The later hypothesis, however, is very difficult to probe.

The results of the present research may expand the knowledge of some discriminative processes involved in the phenomena of linguistic productivity (e.g., Malott, 2003), question answering, rule following, reasoning, and others (e.g., Hayes, Barnes-Holmes, & Roche, 2001), because common control is involved in many instances of these phenomena. Also, these learning processes may serve to improve the design of procedures that could facilitate the emergence of verbal relations in people with learning disabilities, such as children with autism. For example, in order for children with autism to learn to answer questions with two relevant stimuli similar to the examples explained above, the present study suggests that they should learn first to answer questions with only one relevant stimulus (e.g., say names of writers, say names of Spaniards, and so on). It also suggests that perhaps they should learn the relational frame corresponding the two-stimuli question.

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